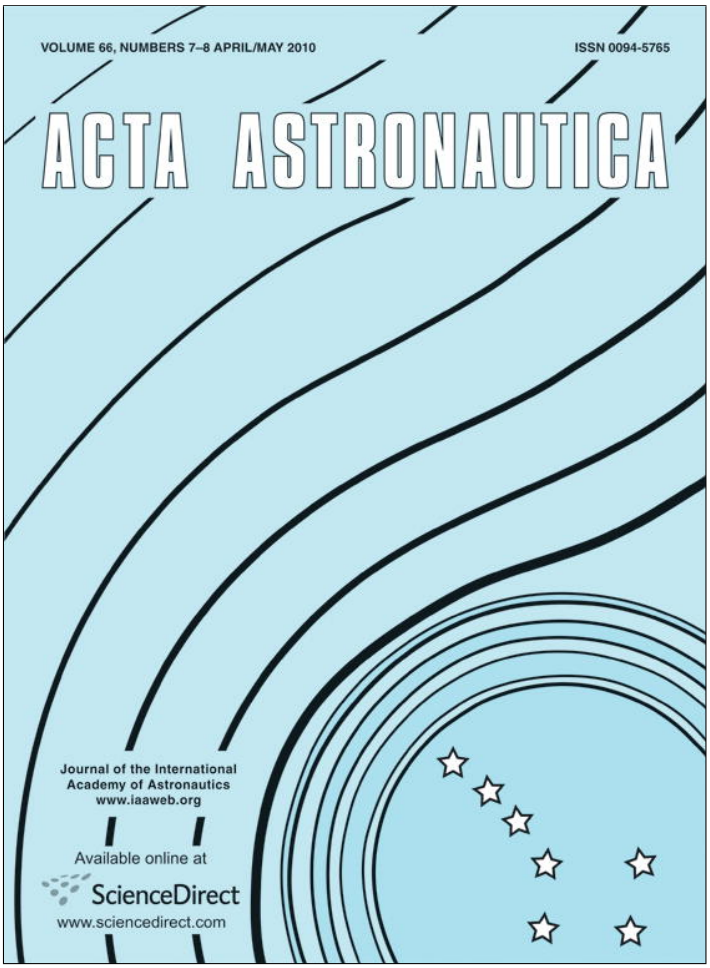

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NASA's explorer school and spaceward bound programs: Insights into two education programs designed to heighten public support for space science initiatives

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ABSTRACT

Introduction: NASA has played an influential role in bringing the enthusiasm of space science to schools across the United States since the 1980s. The evolution of this public outreach has led to a variety of NASA funded education programs designed to promote student interest in science, technology, engineering, math, and geography (STEM-G) careers.

Purpose: This paper investigates the educational outreach initiatives, structure, and impact of two of NASA's largest educational programs: the NASA Explorer School (NES) and NASA Spaceward Bound programs.

Results: Since its induction in 2003 the NES program has networked and provided resources to over 300 schools across the United States. Future directions include further development of mentor schools for each new NES school selected, while also developing a longitudinal student tracking system for NES students to monitor their future involvement in STEM-G careers. The Spaceward Bound program, now in its third year of teacher outreach, is looking to further expand its teacher network and scientific collaboration efforts, while building on its teacher mentorship framework.

1. Introduction

1.1. Overview of NASA space education outreach

Since the 1980s NASA has played a very beneficial role in space education outreach in the United States, inspiring students and teachers across the nation. The induction of such outreach was out of response to the Teacher in Space component that was added to the NASA Astronaut Corps program [1]. Furthermore, since the first educator astronaut selection took place in the 1980s, the evolution of space education outreach to the public has led to a variety of government and privately funded education programs designed to promote student interest in science, technology, engineering, math, and geography (STEM-G) careers [1]; NASA Explorer Schools [2] (Fig. 1).

1.2. Inspiring and connecting the K-12, college/graduate, and professional science communities

To address the STEM-G concern NASA has developed a variety of educational outreach programs to engage students of all ages in STEM-G careers and fields of study. There are two separate divisions of the NASA Education

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Fig. 1. A banner designed by a NASA Explorer School in Sioux City, Iowa encourages students to pursue future space exploration by remembering our past exploration efforts. (*Photo courtesy NASA Explorer School program*).

Office, each with separate financial support for their education outreach objectives, which includes the K-12 education division and the higher education (college and graduate students) division. The overall goal of both is to inspire, identify, and then train/mentor potential students who can move into specific career fields.

A recent approach by which to promote STEM-G has been to connect the following three communities: K-12; college/graduate; and the professional science community. This effort, while somewhat complex due to a variety of reasons (personal agendas, work schedules and timelines, etc.) has been shown to be effective when planned and executed properly. Many colleges with aerospace engineering programs are funded by the federal government to have what is known as Space Grant Consortium. The main purpose of the Consortia is to provide a multitude of outreach initiatives and funding support of both the K-12 and higher education communities, while connecting such outreach to each university institution's. Another example of leadership and support that has made valid attempts to connect all three communities are the math, science, and space coalitions that exist in various states within the US. Examples of such coalitions are: the Iowa Mathematics and Science Coalition (IMSC); the Space Foundation; and the various Challenger Learning Centers located across the US. The focus of such groups is to bring leaders together to collaborate, network, and brainstorm ideas for developing strong support for the future of the Iowa business sector associated with STEM-G careers [3].

1.3. Purpose of the study

This paper investigates the educational outreach initiatives, structure, and impact of two of NASA's largest education outreach programs: the NASA Explorer School (NES) and NASA Spaceward Bound programs. The efforts of these two outreach programs has provided an opportunity for teachers, students, families, and communities to be better informed, inspired, and engaged in the scientific processes and initiatives associated with space exploration.

2. Methods and results

2.1. Structure of the NASA explorer school program

2.1.1. Program overview

The NES program is an education program designed to provide educational outreach to the K-12 community in the US Since its induction of a cohort group in 2003, the NES program has grown to involve and support over 300 schools across the nation. The program is a three-year grant partnership for selected schools, designed to "immerse high minority and high poverty urban and rural schools in NASA mission content" [4,5]. Each school that applies for the grant identifies five school members who serve as school leaders to implement the grant. Such members include four teachers (one who serves as the team lead) and an administrator from the school. Selected schools first receive a technology budget—a total of $17,500 over the course of the three-year grant partnership. Upon awarding NES school selections the first priority of the grant is for those schools who do not have videoconferencing capabilities to purchase the necessary equipment to utilize NASA's Digital Learning Network (DLN) [6]. With the help of this technology, schools have access to a variety of real-time learning programs for students where they can see, hear, and interact live with scientists and engineers at the various NASA centers. After the completion of the third year of the grant partnership, schools are still allowed access to the NES program opportunities, but won't receive added funding support, which is why it is essential for schools to build sustainability during the third year of the grant. In its nine years of existence the NES program has provided outreach opportunities and support that have increased overall student interest and involvement in STEM-G careers (NASA Explorer Schools [2] (Fig. 2)).

2.1.2. Teacher, student and family involvement/opportunities

There are a variety of opportunities that the NES program makes available to teachers, students, and families during the three-year grant partnership. During the first year of the grant teachers are provided with classroom resources and professional development opportunities beginning with a trip to their regional NASA center for a week of orientation and training, followed by an opportunity to attend a National Education Conference (i.e. the National Science Teachers Association (NSTA) conference). Teachers also have the opportunity to sign up for special opportunities such as trips to Antarctica; Spaceward Bound programs that train teachers in the Atacama Desert in Chile; Winter Story in Yellowstone; Robotics Training at various NASA centers; Meteorology trips to Alaska; and many others.

Although the NES outreach begins with teacher opportunities and training, students are ultimately the focus of the program. Students can apply for opportunities

Fig. 2. First ever Spaceward Bound Expedition held in the Atacama Desert of Chile (June 2006). Teachers selected from United States NASA Explorer Schools, as well as from Chile, worked and collaborated along scientists from NASA and other countries around the world. (*Photo courtesy of NASA Ames Research Center*).

Fig. 3. Members of Crew 52 during a simulated surface excursion (SE) (*Photo courtesy the Mars Society*).

to present personal research (i.e. science fair projects) to NASA personnel via the DLN, while also getting involved with group design projects such as the Lunar Base Design Challenge (2007) and the Plant Growth Chamber Project (2008). Through such projects they get feedback from NASA experts and then make modifications before presenting their final design to a panel of experts. Since grant funding simply cannot support the costs associated with students traveling to NASA centers for hands-on learning, teachers provide the hands-on opportunities at the school and then the DLN provides further access to information, updates, and collaboration between the students and NASA scientists/engineers.

The NES program also offers a wide range of support with regards to family involvement, encouraging schools to conduct family events (field trips and/or night events) to get students and their families more involved.

2.1.3. Public outreach

One of the goals of the NES grant is for each selected school's team members to conduct outreach to their fellow staff and the general public. Outreach can be carried out through events such as Family Nights and Space Day Events, which involve not only students from the NES school, but also other non-NES schools that are invited to participate (i.e. elementary schools that feed into a middle school, or schools from other towns who do not have access to the knowledge and resources).

2.2. Structure of the NASA spaceward bound program

2.2.1. Program overview

Spaceward Bound is an educational program for undergraduate students, graduate students, and teachers, developed and managed at NASA Ames and funded by the Exploration Systems Mission Directorate (ESMD). The goal is to provide teachers with opportunities to work alongside of and collaborate with science researchers in the field, while developing ideas on how to leverage their experiences in the classroom upon returning home. The program first began in 2006 with a group of US teachers who were selected to participate in a science research expedition to a Mars analog site in Chile known as the Atacama Desert. Teachers chosen for this first Spaceward Bound program were selected from a pool of teachers who were active members of NES schools across the US (since this selection, the application requirements for other Spaceward Bound programs has been changed to reach a more diverse population of professionals associated with STEM-G careers). During these experiences teachers learn about the various aspects associated with space exploration. Such aspects include: logistics and transportation; energy and life support; human factors; exploration and EVA activities; Moon/Mars science, analog concepts, and theory [7]. From the success of this first Spaceward Bound program, others have arisen that have taken teachers, scientists, and college/university students to places such as: the Utah Desert (Mars Desert Research Station); the Mojave Desert (Zzyzx Research Station); North Dakota; Pavilion Lake in Canada; the Canadian High Arctic; and Lassen Volcanic National Park (Fig. 3).

2.2.2. Collaboration with NASA scientists

The Spaceward Bound program offers graduate students and teachers the opportunity to learn alongside world-class scientists who are developing strategies to search for life on other worlds and methodologies that enable human space exploration of the Moon and Mars. Graduate students and teachers can further develop knowledge and understanding by their involvement with such professionals (Fig. 4).

2.2.3. Leveraging expedition experiences with students

Teachers involved in space analog site expeditions are provided such opportunities with the understanding that the intent is for them to learn the science being conducted at each respective analog site and then develop leveraging activities to share with students upon returning to the classroom. It is through leveraging such lessons that students have an opportunity to replicate science

Fig. 4. Caving team gets ready to enter a collapsed lava tube at the Pisgah lava flow (*Photo courtesy NASA Spaceward Bound*).

activities, giving them the sensation of being a scientist working in the field. Integrating collaborative group work to the experience, students can become more aware of the role that group dynamics plays in positive group cohesion and overall group dynamic development, which is a similar experience in many ways to that of astronauts living and working in space [8].

3. Future suggestions

3.1. The NASA explorer school program

3.1.1. Mentor schools

As of 2009, the NES program has considered implementing a mentorship component to the grant. The idea is that schools either completing the third year of the grant partnership and/or schools that have been successful with the implementation of the NES program in their school and community, would provide mentorship to schools that are either newly selected or are struggling to get effective programs in place. Another suggestion is that NASA designate a small amount of additional funding to allow the team lead of one of the newly selected schools (or struggling schools) to visit the building, staff, and classrooms of their mentor school to get ideas on how to successfully implement the NES concept into the framework of their school's overall mission. This approach is suggested because some schools struggle with the implementation of the NES grant due to either a lack of strong administrative or faculty support. In time, more results will be available for analysis purposes.

3.1.2. Sustainability for the NES program

While there is no magical formula for sustainability, there are ways to increase the likelihood that a program will be in existence in the future. We first suggest that NASA continue to influence state math and science coalitions to support NES schools in their respective states, while increasing support from Space Grant Consortium. We also suggest that NASA consider promoting team-teaching practices between NES schools through the use of the DLN in parallel with the Professional Learning Communities model being utilized in schools across the nation.

Another suggestion is to implement a more effective longitudinal study to track students exposed to the NES program, to see if their involvement leads to the pursuit of STEM-G careers. This suggestion is a large undertaking, but one that could provide data to verify program goals, which is necessary when working to receive annual Congressional approval for the NES budget. Presently the NEEIS program provides NASA with data on how the program is affecting teacher and student interest and engagement in STEM-G careers, but it does not track the long-term progress of the grant.

3.1.3. Future program development and direction

While the future directions of the NES program are in discussion, perhaps this paper can provide some insights into directions the NES program can consider as it looks to analyze such future directions. One suggestion that could increase the effectiveness of NES schools is through finding and utilizing other corporate and NASA education outreach programs. One example of an outstanding corporate outreach opportunity is "Orion's Path", a strategic online education collaboration sponsored by Lockheed Martin, the Space Foundation, and SpaceClass, which has been developed with the intention to inspire and encourage students in STEM careers. Participating students will learn about all aspects of upcoming lunar and Mars missions, including habitats, geology, gravity, water resources, and other mission relevant topics. Use of the program, training materials, and website access is free to teachers.

Another NASA public outreach program that NES schools could take advantage of is the NASA/JPL Solar System Ambassador program. When requested, motivated volunteers come to your school to deliver presentations on space exploration missions and their recent discoveries. With over 500 Ambassadors in all 50 states, Washington DC, and Puerto Rico, there may be a motivated space enthusiast near your school.

3.2. The spaceward bound program

3.2.1. Improving the quality of leveraged activities with students

Developing activities to leverage from a Spaceward Bound expedition can be a challenging task, especially when schools can't afford the equipment that scientists have access to. However, activities do not have to be complex and/or expensive, and with younger aged school children (grades K-5) it is probably best to keep things simple when introducing complex scientific processes. The main focus of activity leveraging is to provide students with an opportunity to follow similar methodologies as scientists do when collecting and analyzing data (Fig. 5).

An example of a variety of leveraged activities that were carried out with students (and their parents) was conducted with four students from an NES school in Sioux

Fig. 5. Students participating in the first ever Student Spaceward Bound experience. The experience was derived from their teacher previously participating in three Spaceward Bound expeditions (*Photo courtesy NASA Spaceward Bound*).

City, Iowa (West Middle School) [9]. The event modeled the approach used by Spaceward Bound investigators both in regards to pre- and intra-mission training. The opportunity involved a three day (two night) experience learning field methodologies while doing so in a simulated space analog environment (semi-remote site located northeast of Stone State Park in Sioux City, Iowa). Students at the school applied for the opportunity to participate, going through a selection process somewhat similar to an astronaut selection process.

3.2.2. Future Program development and direction

With the exploration of the Moon and Mars anticipated to begin around 2020, these missions will be fundamentally field science (geology and astrobiology). The astronauts who will be exploring the Moon in 2020+ and the crew of the Mars base that will follow are anticipated to be in elementary and middle school today. The senior scientists and engineers that will direct these missions are today undergraduate and graduate students. Therefore, for NASA to succeed we must inspire and train these students in field exploration.

With this vision in mind, the Spaceward Bound program has developed an infrastructure through its expeditions that trains higher education students as well as teachers from the K-12 community to learn field exploration techniques that will be used in future exploration efforts. Furthermore, the Spaceward Bound has developed several ideas for promoting future program developments, which involve bringing new interactive tools and web 2.0 approaches to the Spaceward Bound expeditions to reach more teachers and students, while also enabling more science. Such approaches include the following:

- detailed visual data sets of expedition sites;
- data archiving for science use;
- remote virtual participation in field trips;
- high data rate interaction from the field;
- connect to virtual worlds (e.g. 2nd life);
- teleoperation of field robots;
- teleoperation of field loggers & experiments;
- development and testing of field instruments.

The use of such approaches aims to further enhance field science, while furthering the study of life in extreme environments. This is done through building an experience base in field exploration using the tools in field exploration on Earth that astronauts will use in the field exploration on the Moon and Mars in the future.

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